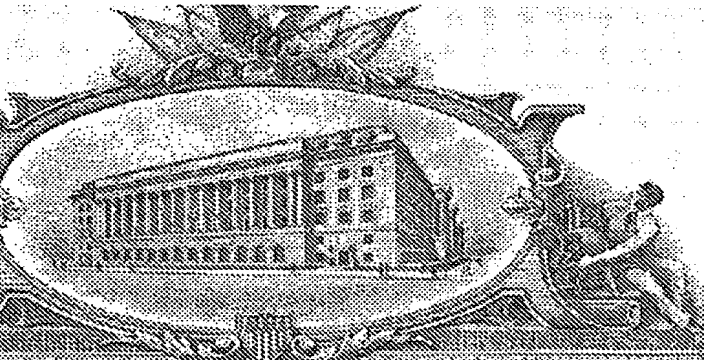


BEST AVAILABLE COPY

1227067



THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

September 17, 2004

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: 60/510,835

FILING DATE: *October 14, 2003*

RELATED PCT APPLICATION NUMBER: *PCT/US04/25221*

Certified by

Jon W Dudas

Acting Under Secretary of Commerce
for Intellectual Property
and Acting Director of the U.S.
Patent and Trademark Office





PTO/SB/16 (08-03)

Approved for use through 07/31/2006. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

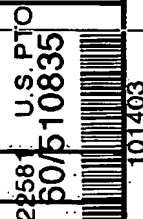
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. ER 002032845 US

INVENTOR(S)					
Given Name (first and middle (if any))		Family Name or Surname		Residence (City and either State or Foreign Country)	
James R.		ZARIAN		Corona del Mar, California	
Additional inventors are being named on the _____ separately numbered sheets attached hereto					
TITLE OF THE INVENTION (500 characters max)					
Light-Emitting Medium and Illumination System					
Direct all correspondence to: CORRESPONDENCE ADDRESS					
<input checked="" type="checkbox"/> Customer Number: 003775					
OR					
<input type="checkbox"/> Firm or Individual Name					
Address					
Address					
City		State		Zip	
Country		Telephone		Fax	
ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/> Specification Number of Pages <u>21</u>					
<input type="checkbox"/> Drawing(s) Number of Sheets _____					
<input type="checkbox"/> Application Date Sheet. See 37 CFR 1.76					
<input type="checkbox"/> CD(s), Number _____					
<input type="checkbox"/> Other (specify) _____					
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT					
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.					
<input type="checkbox"/> A check or money order is enclosed to cover the filing fees.					
<input checked="" type="checkbox"/> The Director is hereby authorized to charge <u>any deficiency in the filing</u> fees or credit any overpayment to Deposit Account Number: 05-0845					
<input checked="" type="checkbox"/> Payment by credit card. Form PTO-2038 is attached.					
FILING FEE Amount (\$) \$80.00					
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
<input checked="" type="checkbox"/> No.					
<input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: _____					



101403

Respectfully submitted,

[Page 1 of 1]

Date OCT. 14 2003

SIGNATURE

REGISTRATION NO. 24,404TYPED or PRINTED NAME Gerry J. Elman

(if appropriate)

Docket Number: ADV1.001TELEPHONE 610-892-9942**USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT**

This collection of information is required by 37 CFR 1.51. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop Provisional Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

LIGHT-EMITTING MEDIUM AND ILLUMINATION SYSTEM

INTRODUCTION

The present invention relates to a light-emitting form which includes a container and a light-transmitting medium as a core. In accordance with an important aspect of the invention, the light-transmitting medium has a relatively lower refractive index than the container. The light-transmitting form may be completely transparent or translucent and when illuminated have a uniform glow and an aura. The container may be of any material that is translucent or transparent and may be of any color. The container material is preferably a polyester.

The raw materials for the light form in accordance with the present invention are less costly than known light forms and offer numerous advantages when compared to other illumination light forms such as light guides, optical fibers and the like. Viscous materials in the form of liquids, oligomers, polymers and copolymers advantageously are a major class of raw materials for the core of the present invention. The core polymers in the range of low molecular weight, water-soluble polymer solutions to highly crosslinked polymers advantageously are a major class of raw materials for the core of the present invention. The container material may be formed from typically available polymers, such as polycarbonates, polymethacrylates, polyacrylates or polyadipates, silicone polymers and may be formed by commonly known processes, such as extrusion, blow-molding and injection molding.

In one embodiment of the invention, a light-emitting form in accordance with the present invention is combined with at least one light-emitting diode (LED), a power source and a switching device to form a self-contained illumination device.

One aspect of the invention provides a light-emitting form comprising, a light-transmitting medium of a lower refractive index, contained within a container of higher refractive index, whereby the light form, when illuminated, glows uniformly and has (or exhibits) an aura. The container may desirably be in a cylindrical form. It may desirably have a linear form. It may desirably be of polyester material. The polyester material may be free of halogen atoms, or it may contain halogen atoms. Alternatively it may be a silicone.

LIGHT-EMITTING MEDIUM AND ILLUMINATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention broadly relates to a light emitting form for transmitting and emitting light at one or more wavelengths. The light emitting form is comprised of a translucent or transparent container of a relatively higher refractive index and a light-transmitting core of relatively lower refractive index, whereby the light form, when illuminated, glows uniformly and has an aura for use in side lighting (side glowing) applications, more specifically, functional lighting applications and/or decorative lighting applications. More specifically, the light emitting form can be tubular (cylindrical) simulating a linear light guide. The container material, for example, may be a polymer and, more specifically, the polymer may be polyester. The polymer molecular structure may be free of fluorine moieties. Furthermore the present invention relates to manufacturing processes for a linear light form that reduces the cost of manufacture and increases the throughput, glow and aura of the light form.

2. Description of the Prior Art

[0002] Various lighting systems are known using light emitting diodes (LEDs). LEDs have been the center of focus because of aesthetic, design flexibility, color changing, long life, small physical dimensions and other attributes that together advantageously serve the intended markets. LEDs as a source of light offer many advantages; moreover, their usefulness is enhanced by the use of optical elements, such as light guides, lenses, refractors, reflectors to disperse, reflect and refract light. As such, LEDs have been combined with various light conduits, such as so called "optical fibers", "fiber optics", "light pipes" and "light guides", collectively categorized as light guides. These lighting systems find use in markets, such as sign, displays, architectural and transportation.

[0003] Light guides are normally made out of polymers, glass, metals or liquids. In particular, light guides, such as the ones disclosed in U.S. Patent Nos. 5,052,778; 4,957,347; 6,278,827; 5,408,641; 5,485,541; 5,898,810 and 6,535,667 and others, and herin incorporated by reference, are formed from an outer sheath or cladding and a polymer core. Invariably, a

polymer of a relatively higher refractive index is used for the "core" and a relatively lower refractive index polymer is used for the "cladding". Additionally, in general, the cladding polymers' molecular structures have fluorine moieties.

[0004] Another class of light guides, for example, as disclosed in U.S. Patent Nos. 4,261,936 and 5,111,526, and herein incorporated by reference, and having substantially smaller diameters compared to the above light guides, comprises of thermoplastic polymer core with a relatively higher refractive index than the cladding polymer. The cladding polymer's molecular structure has fluorine moieties.

[0005] ~~Another type of light guide in the same category, U.S. Patent No. 6,488,397, and~~ herein incorporated by reference, discloses a light guide with a strip of reflective material placed at the core-clad interface to disperse light. The core polymer has a relatively higher refractive index than the cladding. The cladding's molecular structure, however, does not contain any fluorine moieties. In such a light guide, the light dispersion is directional, and no aura is evident.

[0006] In yet another class of light guides, liquid light guides are disclosed. These light guides are normally formed from a thermoplastic cladding and a liquid core. Such liquid light guides fall in two main categories. The first category, mainly used in the medical industry, and intended to transmit light from one point (input or proximal end) to the end point (output or distal end), for example, as disclosed in U.S. Patent Nos. 5,452,395, 6,418,257 and 6,507,688, and herein incorporated by reference. The manufacturing processes for the production of this class of light guides is rather specialized and cost prohibitive for many applications. Normally, a very concentrated salt solution with a higher refractive index forms the liquid core, which is contained in polymer of lower refractive index. In the second category, for example, as disclosed in U.S. Patent Nos. 5,799,124 and 5,896,483, and herein incorporated by reference, illuminating systems for decorative applications are presented. In the latter category, the cladding still has a lower refractive index.

[0007] In general, the above light guides have been designed to create an effect, for example, to create a "neon effect". Neon, a commonly known lighting medium, glows from the sides when activated and commonly has a pronounced aura. This effect is known as neon effect. The light guides disclosed in the U.S. Patent Nos. 5,052,778, 4,957,347, 6,278,827, 5,406,641 and 5,485,541, 5,799,124, 5,898,810 and 6,535,667 in part, and herein incorporated by reference, disclose such light guides.

[0008] To more closely resemble the glow and aura of neon, using light guides, rather inventive steps have been attempted. US Patent No. 5,067,831, and herein incorporated by reference ('831), describes the general concept of the side scattering light guides. '831 discloses

a polymer core having a higher refractive index encased within a transparent fluoropolymer cladding having a lower refractive index. '831 relies on the leakage of light from the cladding through a jacketing to achieve the intended goal.

US Patent No. 20020131275A1, and herein incorporated by reference ('275), uses an "illuminating device that includes a light-guiding member formed of a translucent material" having "a light-emitting region along the length of the light-guiding member, and a plurality of grooves having a rectangular cross-section and formed in the circumferential surface of the light-guiding member at appropriate intervals in the axial direction." '275 does not disclose the use of any cladding.

U.S. Patent No. 4,733,332, and herein incorporated by reference, discloses the use of "optical facets or fine powder" on one side of the core. The fine powder having a refractive index higher than the core, and the core yet having a relatively higher refractive index than the cladding. U.S. Patent Nos. 5,982,989 and 6,169,836, in a similar fashion, allude to the use of fine particles in a higher refractive index core and lower refractive cladding to disperse light in a predetermined manner to emulate a linear light form.

U.S. Patent No. 6,488,397, and herein incorporated by reference ('397), discloses a method to disperse light by "at least one strip-shaped reflecting layer formed by printing on the side surface of the light transmission" core "having a high reflective index". '397 does not disclose the refractive index of "protective sheathing." Similarly, U.S. Patent No. 6,550,952, and herein incorporated by reference, discloses a method to disperse light from a "light pipe", which has a higher refractive index core and a lower refractive index cladding by inventive steps as disclosed therein.

Japanese Patent JP08-094862 A, and herein incorporated by reference, discloses a transparent core encased within a fluoro-rubber cladding. The "fluoro-rubber cladding contains particles such as activated carbon, silica, silica gel, alumina or molecular sieves, zeolite-based absorbent, ion exchange resin, magnesium oxide, calcium carbonate or silver sulfate to trap halogen compounds." By trapping halogen compounds the aforementioned particles stabilize the cladding against a decrease in transmission due to halogen compounds. However the concentration of the aforementioned particles is higher than the optimum level of effective light enhancement and the particles therefore contribute to opacity.

US Patent No. 4,422,719, and herein incorporated by reference ('719), discloses a transparent semi-solid core which is encased within a tubular cladding. '719 discloses the following ways of providing side scattering capabilities: "Scoring the surface of the cylindrical core with angular cuts or discontinuities." This is an expensive and inconsistent method.

4

"Introducing bubbles or foreign materials into the cylindrical core material while the cylindrical core is still molten." The molten state is not well defined, and like similar art, the bubbles and foreign materials contribute to non-uniform and excessive absorption of light. "Introducing powder into the tubular cladding material. For example, titanium dioxide (TiO₂) is present in the cladding material at levels in the order of 2-10%." Similar to the previous way, foreign materials contribute to excessive absorption of light and actually block the transmission of light from the transparent cladding. "Forming the tubular cladding from a material which has an index of refraction exceeding that of the cylindrical core." This method is not well defined and the preferred cladding material, polychlorinated poly-phenyls, ~~does not readily form into a tubular~~ cladding and typically has a very yellow appearance. Ambiguity of '719, in the latter method, does not provide for an advantageous method to achieve the objectives as disclosed. United States Patent No. 6,091,878, and herein incorporated by reference ('878), limits the concentration of additives which are added to the tubular cladding to increase the effectiveness with which light is transmitted circumferentially out of a cylindrical light guide. While '878 addresses some of the deficiencies of '719, the light guides of '878 suffer from a lack of efficiency due to the large angles at which light is scattered by the aforementioned additive. The light guides of '878 along with '719 also require additional manufacturing steps for their formation. For example, one of the methods of '719 requires the formation of angular cuts or discontinuities and the light guides of '878 require the introduction of additives into the tubular cladding.

US Patent No. 5,937,127, and herein incorporated by reference ('127), in general discloses a linear light form, or more specifically a light conduit whereby the overall illuminated diameter of the conduit is maximized while the overall illuminated diameter of light transmitting component is minimized. The advantage disclosed is to "exhibits a larger illuminated diameter using the aura effect", utilizing "conventional thermoset cores and cladding having optimized cross-sectional diameters" to ensure energy efficiency and reduce the cost of production. '127 achieves this objective by utilizing and applying multiple layers of jacket materials onto "the outer periphery of fiber optic core and cladding, to expand the perceived size of the fiber optic core and cladding." '127 further disclosed advantages such as to provide: "a conduit that, when bent, does not exhibit a hot spot; a conduit illuminated generally uniformly across its length; a conduit exhibiting a higher uniformity and a larger appearance in outside diameter; and most importantly a conduit with a perceived "aura". '127's manufacturing process, nonetheless, uses combination of materials, uses "multiple layers... of polymeric jackets" and has numerous steps as disclosed therein, making the light conduit very expensive. '127,

nonetheless, claims to have an aura, a very desirable effect. "Aura" is defined as luminous radiation. The "aura effect" is where luminous radiation appears outside of the core and cladding, and is visible in the space surrounding the linear light form. '127 further points to "bend radius", and hot spots, disclosing it as follows: "Linear light forms, when bent past a certain degree known as permissible "bend radius", appear to have a "hot spot". A hot spot is defined as the area of the optic that appears to be brighter than the rest of the optic. The hot spots can detract from lighting applications wherein the uniformity of the light of the light is desirable. It is thus desirable to reduce the hot spot effect.

US Patent Nos. 5,987,199 and 6,289,150, and herein incorporated by reference ('199 and '150), yet disclose one more elaborate method to create light forms with sufficient light to illuminate an area surrounding the linear light form. The light forms according to '199 and '150, nonetheless are very directional and to very short distances. In summary, the light forms disclosed are a variation of thermoset of relatively higher refractive index and a lower refractive index cladding, manipulated and placed in a channel to reflect the light. The combination of the cuts and the reflection of light off the channel hinder the efficiency of the light form.

Invariably in almost all of light forms such as fiber optics, light guides, light pipes and light conduits or similar modalities – which, for the purposes of this invention would be considered as light forms – are mainly composed of a core and a cladding. The core is the light transmitting medium and the cladding is the immediate layer in contact with the light-transmitting medium that in combination provide total internal reflection useful in light forms. Further, the core has a higher refractive index and the cladding has a lower refractive index. In most of the light forms the cladding molecular structure contains fluorine atoms. Fluorinated or fluorine based molecular structures inherently provide a relatively lower refractive index. Fluorinated polymers with backbones other than carbon, such as silicone have also been used. Fluorinated and fluorine containing polymers are customarily expensive and hard to process.

The light forms discussed above in combination with different light sources such as halogen, xenon, halogen, high intensity discharge lamps or LEDs have been used to create illumination systems to solve the problems associated with traditional neon light systems. However, the light guides discussed above, due to the relatively high cost of raw materials and their corresponding manufacturing processes, are relatively expensive and limited in their applications. There is a need for light forms, which can be formed from relatively less expensive

raw materials and less costly processes, and can be used in a wider range of applications than known light guides.

It is therefore desirable to provide an alternative side glowing light form with substantial aura to those disclosed in the above-referenced patents. It is also desirable to provide an effective method of manufacturing such an alternative side glowing light form.

The applications of the light forms and systems disclosed are primarily in signage, displays, architectural, transportation among numerous others.

SUMMARY OF THE INVENTION

[SOT1] The present invention relates to light emitting forms comprising of a light transmitting medium (core) of lower refractive index encased in a container (cladding) of a higher refractive index, whereby the light form, when illuminated, glows uniformly and has an aura.

[SOT2] In accordance with an important aspect of the invention, light form of the present invention, when illuminated, glows uniformly and has an aura. Aura being the luminous radiation which appears outside and visible in the space surrounding the light form and being substantial to illuminate an object substantially away from the light form.

[SOT3] In accordance with an important aspect of the invention, the light-transmitting core is a liquid, oligomer (telomer), prepolymer or prepolymer precursor, polymer and / or combination thereof, or mixtures of oligomers and / or polymers in a solution.

[SOT4] In accordance with an important aspect of the invention, the liquids core is advantageously selected from oils, salt solutions, water-soluble polymers, water solution of water-soluble polymers, solution of water-soluble polymers, organic compounds of lower molecular weight, solution of oligomers, prepolymers and polymers among other liquids.

[SOT5] In accordance with an important aspect of the invention, the oligomer core is advantageously selected from oily oligomers, oligomers of water-soluble polymers and copolymers, oligomers of esters, carbonates, acetals, amides, acrylamides, vinyl ethers, vinyl acetates, vinyl esters, acrylic acids, acrylates, methacrylates, allyl esters, styrenes, adipates and silicones.

[SOT6] In accordance with an important aspect of the invention, the prepolymer or precursor of the core is advantageously selected from prepolymer of water-soluble polymers and or copolymers, prepolymer or pre-copolymer of esters, carbonates, acetals, vinyl ethers, vinyl acetates, vinyl esters, acrylic acids, acrylates, methacrylates, allyl esters, styrenes, adipates and silicones. Additionally the prepolymer as a precursor may be converted to a thermoplastic or thermoset polymer in situ.

[SOT7] In accordance with an important aspect of the invention, the polymeric or copolymer core is advantageously selected from thermoplastic or thermoset classes. The thermoplastic class is selected from the esters, carbonates, acetals, amides, acrylamides, vinyl ethers, vinyl acetates, vinyl esters, acrylic acids, acrylates, methacrylates, allyl esters, styrenes, urethanes and

silicones. The thermoset is selected from the class of esters, carbonates, acetals, amides, acrylamides, vinyl ethers, vinyl acetates, vinyl esters, acrylic acids, acrylates, methacrylates, allyl esters, styrenes, adipates and silicones.

[SOT8] In accordance with an important aspect of the invention, the core medium is purified by filtration, distillation, use of molecular sieves, use of centrifuge force, crystallization and or combinations of.

[SOT9] In accordance with an important aspect of the invention, the liquids, oligomers, prepolymers, polymers and copolymer of the core or / and in combination with other precursors is advantageously poured, pumped or vacuumed into the cladding; and there is no limitation as to the temperature, pressure or combination thereof, used at the time of processing.

[SOT10] In accordance with an important aspect of the invention, the precursor of the thermoplastic polymer or copolymer core is made prior to placement into the container. The precursor, in accordance with an important aspect of the invention, has a syrupy consistency and is capable of being further polymerized to a more completed polymerized state. The precursor is poured, pumped, vacuumed into the cladding and polymerized in situ.

[SOT11] In accordance with an important aspect of the invention, the thermoset polymer core is made of cross-linking ingredients and placed into the container and cross-linked in situ.

[SOT12] In accordance with an important aspect of the invention, the raw materials for the core, is less costly and easier to process in comparison to prior art.

[SOT13] In accordance with an important aspect of the invention, the container is advantageously selected from a material that is translucent or transparent and, when illuminated, in combination with the appropriate core material, glows uniformly and has an aura.

[SOT14] In accordance with an important aspect of the invention, the container is advantageously selected from a material that is translucent or transparent and, when illuminated, in combination with the appropriate core material, glows uniformly and has an aura. Aura being the luminous radiation which appears outside and visible in the space surrounding the light form and being substantial to illuminate an object substantially away from the light form.

[SOT15] In accordance with an important aspect of the invention, the container material may be formed from commercially available polymers and or copolymers, such as polyesters and may be free of halogens; or commercially available polymers and or copolymers silicones.

[SOT16] In accordance with an important aspect of the invention, among the halogen-free polymer or copolymer are polycarbonates, polyacetals, polyamides, polyacrylamides, polyvinyl ethers, polyvinyl acetates, polyvinyl esters, polyacrylic acids, polyacrylates, polymethacrylates, polyallyl esters, polystyrenes, polyadipates and silicones.

[SOT16] In accordance with an important aspect of the invention, the cladding is a halogenated derivative of polycarbonates, polyacetals, polyamides, polyacrylamides, polyvinyl ethers, polyvinyl acetates, polyvinyl esters, polyacrylic acids, polyacrylates, polymethacrylates, polyallyl esters, polystyrenes, polyadipates and silicones.

[SOT16] In accordance with an important aspect of the invention, the silicon copolymers, blends and or derivatives are used for the cladding.

[SOT17] In accordance with an important aspect of the invention, the container is formed by commonly known processes, such as casting, vacuum forming, extrusion, blow-molding and injection molding.

[SOT18] In accordance with an important aspect of the invention, the container is formed into long cylindrical tubes with a uniform cross section, providing a form such as light guides, optical fibers and fiber optics.

[SOT19] In accordance with an important aspect of the invention, the tubular container has cross sections other than round.

[SOT19] In accordance with an important aspect of the invention, the tubular container has an asymmetric cross section.

[SOT19] In accordance with an important aspect of the invention, the container is soft or rigid and or formable.

[SOT20] In accordance with an important aspect of the invention, the light emitting medium is combined with at least one light emitting diode (LED), a power source and a switching and / or controlling device (light emitting element) to form a self contained illumination device.

[SOT21] In accordance with an important aspect of the invention, the light emitting element is immersed in the core material.

[SOT21] In accordance with an important aspect of the invention, the light emitting element is attached to the core material.

DETAILED DESCRIPTION

The present invention relates to a light emitting forms and illumination systems. The light emitting form includes a container, which acts as an outer cladding and a core material whereby the core has a lower refractive index and the cladding has a higher refractive index; additionally, the light form, in combination with a light emitting element like a light emitting diode, glows uniformly and has an aura.

Uniform glow for the purposes of this invention relates to light forms that have a ~~uniform glow from one end to the other end of the light form over a~~ substantial linear length. The length may be less than 0.5 meter to over 10 meters. And, aura relates to light emanating from the light form to actually illuminate an object in proximity of the light form. For the purposes of this invention, the emanating light is adequate enough to make an object visible at least at a distance five times the diameter of the light form. For instance, an object placed 5 cm away in any direction from a 1 cm diameter light form should be readily illuminated and visible. In another way of explanation, at least 10% and preferably 50% of the light intensity at the surface of the light form is measurable at a distance five times the diameter.

Prior light forms did not offer such an advantage, hence the need for the invention disclosed in U.S. Patent Nos. 5,937,127; 5,987,199 and 6,289,150, notwithstanding that the invention required a very powerful, power inefficient light source such as a halogen or high intensity discharge lamp.

For example, in one of the embodiments according to present invention, the core may be formed from liquid materials such as dimethyl cyclic siloxane, a "silicone oil", with a refractive index of 1.395-1.397 and a cladding made from a polyadipate such as an ether-based polyurethane with a refractive index of 1.5-1.6. The cost of the core raw materials associated with such a combination is significantly less than known light guides. Further, the use of a silicone based material substantially reduces the flammability of the light form.

Another advantage of the present invention is additionally realized in the cost of materials and cost of production. Known light guides, as disclosed in U.S. Patent Nos. 4,261,936, 5,111,526, 5,052,778, 4,957,347, 5,406,641 and 5,485,541, function similarly, although not as efficiently, compared to the light emitting form in accordance with the present invention; however, the cost of raw materials is much higher. Additionally, the cost of manufacturing is much higher due to the capital costs and labor associated with the process. The advantages of the present invention is particularly more pronounced for light emitting mediums with high volumes, such as a container with a diameter of 50 mm and larger.

CORE MATERIALS, PROCESSES AND METHODS

As an important aspect of the invention the core of the light emitting medium is a liquid, oligomer (telomer), prepolymer, polymer, copolymer and / or combination thereof, or mixtures of oligomers and / or polymers in a solution.

Various liquids are contemplated for use as the core with the present invention. Exemplary liquids selected from oils such as, mineral oils, fluorinated oils, silicone oils; or liquids in the form of salt solutions, such as aqueous solution of inorganic salts (i.e. sodium chloride, potassium sulfate...), aqueous solution of organic salts (i.e. potassium esters...) proved suitable for the present invention.

Another advantage of the core materials of the present invention is realized by the aqueous mixture ingredient possibilities, which can render the light system more user friendly, environment friendly, inflammable, partially biodegradable among other positive attributes.

Another class of liquids suitable for the present invention is the class of water-soluble polymers such as polyglycols. Polyglycol P425 supplied by Dow Chemicals, Midland, Michigan, purified in neat form, resulted in satisfactory result. Water solutions of the same compound, in ratios of less than 1% to 99.9%, also proved suitable. Polyglycol P425 reportedly has a refractive index of 1.447 was combined as core with a polyadipate tubing with a refractive index of 1.5-1.6 to create a suitable light form according to the present invention.

Any derivatives, forms, combinations of the water-soluble polymers including, water-soluble salts, anionic, cationic, nonionic, cross-linked (hydrogels) and non-cross-linked, modified and unmodified species combined and derived from monomers, pre-polymers, polymers, co-polymers may be used according to this invention.

Conversely, lower molecular weight organic compounds such as ethylene glycol, propylene glycol, benzene, methanol, ethanol, which all have a lower refractive index compared to polyadipate, the cladding material, proved suitable.

Solution of oligomers of propylene glycol in propylene glycol, oligomers of methyl methacrylate in methyl methacrylate, oligomers of styrene in methyl methacrylate also proved suitable in practicing the present invention, when using polyadipates with a relatively higher refractive index as cladding.

Liquid prepolymers or syrupy polymers of materials such as methyl methacrylates, 2-ethylhexyl methacrylates, styrene, 2-ethylhexyl acrylate proved suitable for the present invention. Similarly, liquid solutions of poly(2-ethylhexyle methacrylate) in methyl methacrylate, in benzene, in methyl ethyl ketone and in pentene, by way example, also

proved suitable. By purifying and de-airing the core medium (e.g. removing any air or other gaseous matters from the core medium under low pressure prior to placing the core medium in the cladding), satisfactory light forms were prepared in accordance with the present invention. Contrarily, according to U.S. Patent Nos. 4,261,936, 5,111,526, 5,052,778, 4,957,347, 5,406,641 and 5,485,541, there is a high chance that bubbles can form or the polymer mass degrade because of highly exothermic polymerization reaction temperatures. Problems also ensue due to excessive shrinkage upon polymerization. Other polymerization methods such as emulsion and solution will result in non-transparent masses, which is not conducive to the objectives of the present invention.

US Patent Nos. 4,108,923; 4,077,755; 3,966,693; and 3,907,727 among others disclose methods as how a syrupy mixture of polymer or copolymer may be prepared.

When polymeric cores better suited an application, prepolymers proved useful as precursors for the production of such polymeric cores. In one instance, a prepolymer of 2-ethylhexyl methacrylate was prepared and injected into a suitable cladding (i.e. polyadipate cladding), and further cured at a higher temperature in a water bath. The resulting light form was satisfactory. Use of prepolymers as a precursor is highly desirable for many reasons including, but not limited to, low shrinkage upon further polymerization and ease of placement into the cladding.

Other desirable core polymers are:

Poly alcohols	Polyols
Polyethylene glycols	Polypropylene adipate
Polydimethylsiloxane	Polypropylene glycol
Polyester plasticizers	Polysilane
Polyglycol distearates	Polysiloxane
Polyhydric alcohols	

Unique properties of crosslinked polymers prove desirable at times, for both the core and cladding. For instance, among the more desirable properties are resistance to high temperature, being less infusible and less impermeable to moisture and undesirable gases. Crosslinked polymeric cores may be prepared utilizing prepolymers or monomer mixtures. In preparing a crosslinked cores, prepolymer of methyl methacrylate was combined with 0.1 to 1% by weight of diethylene dimethylmethacrylate prior to placement in a suitable cladding and cured at high temperature, to obtain satisfactory results. The cladding of polyadipate (i.e. an ester based polyurethane) had a higher refractive index than the completely polymerized, crosslinked core.

It is contemplated that crosslinked claddings can be used to form light forms according to the present invention. Any of the core materials as disclosed above are contemplated to prove useful in forming light forms according to the present invention, provided that the core material has lower refractive index in comparison to crosslinked cladding.

Another way to prepare desirable polymeric cores is to use monomers as a precursor. Some of the advantages are relatively lower monomer mixture viscosity, fewer processing steps and raw material cost. In one embodiment, highly purified 2-ethylhexyl methacrylate was combined with Trigonox ADC (e.g. peroxydicarbonate mixture) initiator, supplied by Akzo Nobel of Dobbs Ferry, New York, and injected into an ester-based polyurethane tubing, the tubing was capped at one end, kept on a roll, under pressure, in a cold compartment to avoid premature initiation. The capped end of the tubing, while pressurized, was introduced into a hot water bath at a constant rate to initiate polymerization. A substantial length was polymerized in this manner; although, some of the tubing was wasted as the polymerizing monomer mixture shrank upon polymerization and was forced toward the capped end. In this manner, a progressive and continuous method of production was established. It is contemplated that by continually introducing monomer mixture into the tubing the problem of the waste would be alleviated. Nonetheless, the resulting composition was satisfactory. It is further contemplated that co-polymer or crosslinked polymer cores can be produced by selecting appropriate precursor monomer mixtures.

In another method, for example, n-butyl methacrylate was fully polymerized using an appropriate amount of Trigonox ADC as the initiator, at high temperature, under pressure in a closed system. The polymer mass, while kept molten, was then put under negative pressure, for an extended time, to remove any unreacted initiator, monomer or other volatiles. The molten mass was then injected into a polyurethane tubing kept at a high temperature, in a hot oil bath, to facilitate the flow of the polymer. The combination of core / cladding was then removed from the bath and allowed to cool to room temperature. Effectively, a polymer mass as core material with a low refractive index is introduced into a cladding material with a higher refractive index.

The light form was satisfactory for the purposes of this invention; although it is not clear if such a process is commercially cost effective.

Hydrogels, for example, as disclosed in U.S. Patent Nos. 3,947,401; 4,450,262; 4,540,743; 4,492,776; 4,640, 965; 4,694,037; and hereby incorporated by reference, offer another class of core materials. In general, the referenced patents disclose methods for cross-linking water-soluble monomers, pre-polymers and copolymers and / or combinations thereof into hydrogels. The cross-linking may be done in-situ with the appropriate crosslinkers. It is

contemplated that crosslinking may be undertaken by different methods, for instance, heat may be used to initiate the reaction, or methods such as UV curing as disclosed in U.S. Patent Nos. 5,010,141, 5,532,287 and 5,955,242, hereby incorporated by reference among other methods. It is also noted that UV-curable hydrophilic pre-polymers and polymers and water-swelling polymers may also be used. For example, silicone-containing hydrogels, or derivatives thereof such as the ones disclosed in U.S. Patent Nos. 4,640,941, 5,010,141, 5,387,632, and hereby incorporated by reference, may be used as long as the refractive index of the resulting hydrogel is lower than the refractive index of the cladding.

As with any other light transmitting media, the core materials of the present invention offer the optimum result when the material is free of physical defects such as bubbles or impurities that may cause adverse scattering, or impurities that would cause light absorption. The core / clad interface presents another important factor to be considered. For relatively longer light forms, the light scattering at the interface must be minimized; while, for shorter lengths where more dispersion of light may be desirable, the interface may be manipulated to achieve the desired effect.

Additionally, the core compositions of the present invention conveniently allow inclusion of light dispersing agents such as glass or metal flakes, fluorescing, frequency shifters, micro-bubbles among others if desired.

In order to enhance the dispersion of light, dispersing agents may be introduced either into the core material or into the cladding at various stages of production. In one exemplary embodiment of the present invention, 0.015 Hex / VM 2000 Glitter provided by Minnesota Mining and Manufacturing, St. Paul, Minnesota was mixed in a transparent viscous liquid of polysiloxane and injected into a suitable tubing. A 100 cm light emitting device lit at each end by an LED supplied by Kingbright, Inc., Walnut, California exhibited a dazzling, yet uniform illumination.

CLADDING MATERIALS, PROCESSES AND METHODS

In many known light forms such as light guides as disclosed in U.S. Patents 5,052,778 and 4,957,347, cladding materials with a relatively lower refractive indices are used. For instance, fluoropolymers and silicones, which inherently have a lower refractive indices. These class of materials have a higher raw material cost and are costly to process. Fluoropolymers' relatively higher specific gravity, additionally, exacerbates the fluoropolymers' shortcomings. In order to overcome these shortcomings, the cladding wall thickness has been made very thin and substrates surrounding the fluoropolymer devised '831. Such systems suffer in many areas. For instance, in the course of polymerization, the high shrinkage of the

polymerizing mass causes the fluoropolymer cladding to collapse resulting in a non-uniform cross section. Further, the high shrinkage causes the core to separate from the fluoropolymer, leaving a gap as a result of de-lamination of the core from the cladding. The latter led to the use of heat shrink tubing, which, in turn, introduced more steps in the production of the light guides. The present invention obviates these shortcomings by using polymers such as polycarbonates, polyvinyl acetates, polyvinyl ethers, polymethacrylates, polyacrylates, polyadipates silicone polymers among other suitable materials that, although have a higher refractive index, are less costly, have lower specific gravity and relatively lower processing costs. These transparent, formable materials are also much more environmentally friendly.

In another aspect of the present invention, the cladding or container of the light form is not limited to a circular cross-section, which simplifies overall production. Claddings or containers are contemplated with circular as well as noncircular asymmetrical cross-sections, which in addition do not require complicated processing. In contradistinction, U.S. Patent Nos. 5,052,778, 4,957,347, 4,261,936 and 5,111,526, require that the core cross section be essentially limited to circular. Known light guides with noncircular cross-sections, such as disclosed in U.S. Patent Nos. RE 36,157; 4,957,347 and 5,052,778 require a series of rather complicated and cumbersome processes for the production of light forms with other than round cross sections. The light forms of the present invention can easily be configured to have asymmetric and other than round cross sections. Moreover, the production steps are minimized resulting in substantial cost savings. It is contemplated that claddings, for example, with a round interior and a square, square interior and square exterior or asymmetric exterior can easily be extruded in one step using polycarbonates, polymethacrylates, polyacrylates or polyadipates resins.

In accordance with an important aspect of the invention, the suitable cladding material, including polycarbonates, polymethacrylates, polyacrylates or polyadipates among other resins is free of halogens such as chlorine, fluorine and bromine. It is within the scope of the present invention, nonetheless, to use halogenated resins such as polycarbonates, polymethacrylates, polyacrylates or polyadipates. Conversely silicone polymers, although, more costly than other the resins mentioned above, proved suitable. The silicone resins, similarly, may be free of halogens or halogenated.

Known conventional processes such as casting, extrusion, vacuum forming, blow, slush, rotational and injection molding among other processes proved suitable in the production of the cladding of the present invention. For instance, a poly(methyl methacrylate) tubing with a round, symmetrical cross section, formed using a conventional extrusion processing

proved suitable. Precautions were exercised to assure that the poly(methyl methacrylate) tubing wall was free of any foreign particles and of any degradation. As may be expected, a comparative tubing made by casting proved to show less absorption or scattering of light. Under proper conditions, cylindrical tubings containing the appropriate core materials, when illuminated provided light forms similar to light guides or optical fibers.

Polyadipates with refractive indices of 1.5-1.6, relatively low cost, flexibility at low temperatures, resistance to ozone and oxygen with other desirable characteristics proved to be exceptionally suitable as cladding materials. However, polyadipates are hygroscopic and hydrophilic, and in applications where the light form may be exposed to high moisture or used under water, the moisture reaching the core causes cloudiness hindering light transmission and emission. According to an aspect of the present invention, the use of a water-soluble liquids, oligomers or polymers alleviates this problem. As a result of the water-solubility of the core medium, water molecules reaching the core are readily absorbed by the core material without causing cloudiness. Among the suitable core materials compatible with polyadipates are hydrogels (i.e. poly(hydroxyethyl methacrylate)), polymers such as poly glycols with a molecular weight of 100-4000 and higher and refractive indices in the range of 1.44-1.46, water-soluble oligomers and liquids such as water-soluble silicone oils with refractive indices of 1.40-1.47. Light forms made using the combination as disclosed and placed at relatively very high humidity and underwater for long periods of time (over 60 days) did not exhibit any deterioration of light transmission and emission. The same qualities were observed at extreme temperatures (e.g. below -20° C above 60° C).

Other desirable cladding resins and / or precursors for the production of desirable resins are:

Polyalkylene terephthalates	Polyethylene terephthalate
Polyallyl diglycol carbonate	Polyethylene-propylene adipate glycol
Polyarylates	Polyhydric alcohols
Polyacryloxysilane	Polyols
Polybutylene adipate glycol	Polypropylene adipate
Polycarboranesiloxane	Polypropylene glycol
Polycyclohexylenedimethylene terephthalate	Polysilane
Polydimethylsiloxane	Polysiloxane
Aromatic polyesters	Polytetrahydrofuran
Saturated polyesters	Polyvinyl acetate
Unsaturated polyesters	Polyvinyl alcohol
	Polyvinyl butyral

The process for making the embodiments of the present invention can be fully automated and continuous. For example, the light transmitting core may continuously be inserted into tubing as the tubing is being formed through a conventional extrusion process. Downstream, the tubing containing the core material can be pinched off, cut and a light source placed in and sealed.

Conventional methods for placing and sealing can easily be used. Multiple layered tubing, or tubings with appropriate coatings can be used according to the present invention. However, the refractive index, transparency, degree of purity of the multiple-layered container or coating among other factors must be considered in order to not adversely affect the spirit of the invention. Conventional processes may be used for applying a coating or coatings, such as, spray coating, dipping, vacuum coating among others. UV curing coatings can potentially be used. The coating can be applied onto the container prior or after the core has been included. For multilayered containers, in order to eliminate any chance of foreign elements to permeate into the container, a multi-layered container including a barrier layer may be used. The barrier layer may actually be a tie-layer, or be the layer in contact with the light transmitting medium or be the outermost layer of the container

EXAMPLES

Example 1 - a 100 cm long, 6.5 mm inside diameter, 8.0 mm outside diameter of an ether-based polyurethane was filled with a very viscous, water clear, purified oil supplied by STE Oil Company of San Marcos, Texas. One Agilent LED (HLMT-PG00), San Jose, California was inserted at each end of the tube, immersed in the oil and lit. The light emitting device glowed uniformly along its entire length and had an aura very similar to neon, although not as bright. The polyurethane tubing's refractive index was reported at 1.54 and the oil's refractive index was lower.

Example 2 - Example 1 was repeated with a longer length tubing (e.g. 200 cm). The device, as expected, did not exhibit a uniform glow throughout the entire length of the device and was not as bright as Example 1.

Example 3 - To overcome the shortcoming of Example 2, Example 2 was repeated except Omron red 2MDR01-85R1A LEDs, Schaumburg, Illinois, with higher intensity and a narrower viewing angle as compared to Agilent LED (HLMT-PG00) were used. The light emitting device glowed uniformly along its entire length and had an aura very similar to neon, although not as bright.

Example 4 - Example 1 was repeated except that 3.0 mm inside diameter, 4.0 mm outside diameter tubing from the same supplier was fitted with a Kingbright 3 mm W7104 SEC/H LEDs, Walnut, California. The light emitting device glowed uniformly along its entire length and had an aura very similar to neon, although not as bright.

Example 5 - a cast poly(methyl methacrylate) tubing with a 14 mm inside diameter and 17 mm outside diameter was filled with low molecular weight poly glycol. Due to the rigidity of the tubing, it was difficult to create a sealed device. Nonetheless, a red Luxeon Emitter supplied by Lumileds Lighting, LLC, San Jose, California was placed at one end and activated. The lighting device glowed uniformly and had a substantial aura. The uniform look was somewhat blemished because of the scratches on the surface of the poly(methyl methacrylate).

ILLUMINATION SYSTEM

The light emitting form discussed above may be combined with other components to form an illumination system. In particular, the light form may be combined with one or more illumination assemblies to form an illumination system. In particular, one embodiment for supplying light into the containers of the present invention or into the light transmitting medium is an illumination assembly which contains any combination of LEDs, light directing component(s), reflector and / or refractor component(s), switching device(s), logic component(s), control(s) and energy component(s), or any other components attributing to the transmission and dispersion of light.

Such illumination assembly as alluded to above can be incorporated on one or both ends of a light form of the present invention, to form an illumination device. Various formats for the incorporation of the illumination assembly are contemplated. In one embodiment, the light element may have an extended collimating device in contact with the core and held in place using a compression fitting to hold the container and the light assembly together. In yet another embodiment, in which the container is formed as a tube, the illumination assembly may be inserted into one or both end of the tube to create a device resembling neon.

It is understood that the characteristics of illumination assembly such as the illumination assembly size, the illumination assembly physical configuration, focusing subassemblies, the angle of projected light (e.g. viewing angle), light element clustering (e.g. cluster of LEDs arranged sparsely on a substrate, in comparison to a cluster of the same number of LEDs arranged more compactly), collimation of projected light, light frequency, color mixing among other factors, profoundly affect the light transmission and dispersion, and subsequently, the glow and aura of light form of the present invention.

APPLICATIONS OF ILLUMINATION DEVICE

Any light sources such as halogen, xenon and high intensity discharge lamps can be used in the illumination devices of the present invention. However, LEDs are preferred, because of monochromaticity, low voltage, energy efficiency, ruggedness, compact size, ease of collimation and focusing among other attributes. The combination of LEDs and the present invention can be used in different manners to create efficient light forms and systems with uniform glow and substantial aura.

A tubular lighting system of the present invention with appropriate LEDs, resembled "neon look"; neon is widely used in the sign, display and illumination markets. The present invention further offers other advantages such as energy efficiency, color changing,

digital addressability, flexibility in design, biocompatibility, resistance to vibration and shock, ease of mass production among many others obvious in the art.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. Thus, it is to be understood that,

the invention may be practiced otherwise than as specifically described above.

Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/US04/025221

International filing date: 04 August 2004 (04.08.2004)

Document type: Certified copy of priority document

Document details: Country/Office: US
Number: 60/510,835
Filing date: 14 October 2003 (14.10.2003)

Date of receipt at the International Bureau: 24 September 2004 (24.09.2004)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)



World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☒ GRAY SCALE DOCUMENTS
- ☒ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.